POLISHING APPARATUS

BACKGROUND OF THE INVENTION

The present invention relates to a polishing apparatus for polishing a substrate, such as a semiconductor wafer. Specifically, the present invention relates to a polishing apparatus including a novel dresser device. The dresser device is used for regeneration (dressing or conditioning) of a polishing surface of a polishing pad or a polishing plate comprising abrasive particles.

A conventional polishing apparatus of the above-mentioned type is shown in Fig. 1. In Fig. 1, the polishing apparatus comprises a turntable 1 having a polishing pad 2 covering an upper surface thereof and a substrate holder 3 for holding a substrate (not shown) to be polished, such as a semiconductor wafer. A substrate is held on a lower side of the substrate holder 3 and is pressed against a polishing surface of the polishing pad 2 on the turntable 1. While pressing the substrate against the polishing surface, an abrasive liquid is supplied onto the polishing surface, and relative movement between the polishing pad 2 and the substrate is conducted by rotating the turntable 1 in a direction indicated by an arrow A and rotating the substrate holder 3 in a direction indicated by an arrow B. Thus, the substrate is polished to a flat and mirror-finished surface. It should be noted that a polishing plate comprising abrasive particles may be used, instead of the polishing pad 2.

In this apparatus, the polishing surface of the

polishing pad 2 becomes clogged after polishing of a plurality of substrates, to thereby lower an efficiency of polishing. Therefore, when a predetermined number of substrates have been polished or the efficiency of polishing has been lowered due to clogging, the polishing surface is scraped for dressing, by means of a dresser 4.

The dresser 4 comprises a dresser tool 5 and a dresser shaft 6 for supporting the dresser tool 5. The dresser shaft 6 is adapted to be rotated by means of a rotary mechanism (not shown) in a direction indicated by an arrow C. The dresser tool 5 is adapted to be pressed against the polishing pad 2 by means of an air cylinder 7 and the dresser shaft 6. An annular projection 5a is formed on a lower surface of the dresser tool 5. The annular projection 5a is formed from a member (such as a diamond pellet) containing diamond particles or a hard material such as a ceramic material. A relative movement between the dresser tool 5 and the polishing pad 2 is conducted by rotating the dresser shaft 6 and the turntable 1, to thereby scrape the polishing surface of the polishing pad 2 for dressing.

For effecting dressing of the polishing surface of the polishing pad 2, air is supplied through the controller 8 to the air cylinder 7, so as to press the dresser tool 5 against the polishing pad 2 under a predetermined pressure. Therefore, the minimum pressure applied to the polishing pad 2 (the pressure when no air is supplied through the controller 8 to the air cylinder 7) is equal to the total of the weight of the dresser tool 5 and the weight of the

dresser shaft 6.

During dressing, as shown in Fig. 2, the rate (mm/hr) of scraping of the polishing pad 2 is proportional to the pressure applied to the polishing pad 2. Generally, the total of the weight of the dresser tool 5 and the weight of the dresser shaft 6 is about 10 kg, so that it is impossible to reduce the pressure applied to the polishing pad to less than 100 N (Newton). Therefore, the polishing pad 2 is scraped at a high rate, leading to a rapid wear of the polishing pad 2.

SUMMARY OF THE INVENTION

In view of the above, the present invention has been made. It is an object of the present invention to provide a polishing apparatus for polishing a substrate comprising a turntable having a polishing surface, a substrate holder for holding a substrate and bringing the substrate into contact under a pressure with the polishing surface to polish the substrate, a dresser including a dresser tool adapted to be brought into contact under pressure with the polishing surface to dress or condition the polishing surface and a pressure device connected to the dresser tool for moving the dresser between a raised position where the dresser is spaced away from the polishing surface and a dressing position where the dresser rests on the polishing surface such that the dresser tool is in contact with the polishing surface under a pressure exerted by the weight of the dresser itself. The pressure device includes a member for applying an upward force to the dresser to decrease the

pressure and a downward force to the dresser to increase the pressure.

By this arrangement, the pressure between the dresser tool and the polishing surface of the turntable can be adjusted to a level less than that generated by the weight of the dresser itself. Therefore, dressing of the polishing surface can be conducted while suppressing a rapid wear of the polishing surface.

The dresser may comprise a dresser shaft connected to the dresser tool and extending upward vertically from the dresser tool and the pressure device may comprise a cylinder equipped with a piston to which the dresser shaft is connected. A kinetic frictional resistance against movement of the piston in the cylinder is preferably 0.5 kg or less. First and second pressure supply devices may be fluidly connected to the cylinder so that the first pressure supply device supplies a pressurized fluid to the cylinder to apply an upward force to the piston and the second pressure supply device supplies a pressurized fluid to the cylinder to apply a downward force to the piston.

By preliminarily supplying a pressurized fluid to the above-mentioned cylinder so as to cancel the weight of the dresser out, the pressure between the dresser tool and the polishing surface of the turntable can be easily minimized to a level less than the weight of the dresser and adjusted to an arbitrary value exceeding that level (for example, a value in a range of 10 N to 300 N).

In accordance with another aspect of the present

invention, there is provided a polishing apparatus comprising a turntable having a polishing surface, a substrate holder for holding a substrate and bringing the substrate into contact under pressure with the polishing surface, a dresser tool adapted to be brought into contact under pressure with the polishing surface to dress or condition the polishing surface, and a dresser tool holding device for holding the dresser tool and moving the dresser tool between a raised position where the dresser tool is spaced away from the polishing surface and a dressing position where the dresser tool rests on the polishing surface with a pressure being exerted by the dresser tool on the polishing surface by the weight of the dresser tool itself.

By this arrangement, there is no possibility that a pressure exceeding the weight of the dresser tool will be applied to the polishing surface. Therefore, dressing of the polishing surface can be conducted while suppressing a rapid wear of the polishing pad or plate.

The dresser tool holding device may support the dresser tool in such a manner that the dresser tool is substantially freely movable in a vertical direction relative to the dresser tool holding device.

The dresser tool holding device may comprise an air cylinder equipped with a piston connected to the dresser tool to move the dresser tool between the raised position and the dressing position, and there may be provided a shaft extending vertically and having a lower end connected to the

dresser tool and an upper end connected to the piston. The dresser tool may be freely movable in a vertical direction relative to the lower end of the shaft. The shaft may be provided at its lower end with a flange extending radially outwardly from the lower end and having vertical through holes formed therein and the dresser tool may be provides with a plurality of vertical connecting pins extending through the through holes of the flange. Each of the connecting pins may be provided with a head adapted to be engaged with an upper surface of the flange when the dresser tool is positioned at the raised position. There may be provided an automatic aligning roller bearing connected between the flange and the dresser tool so that the dresser tool can tilt in compliance with undulations on the polishing surface.

The foregoing and other objects, features and advantages of the present invention will be apparent from the following detailed description and appended claims taken in connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 shows an example of a general arrangement of a conventional polishing apparatus.

Fig. 2 is a graph showing a relationship between the pressure of a dresser tool and the rate of scraping of a polishing pad.

Fig. 3 is a view showing an example of a general arrangement of a polishing apparatus in accordance with an embodiment of the present invention.

Fig. 4 is a sectional view showing a dresser of a polishing apparatus in accordance with another embodiment of the present invention.

Fig. 5 is a sectional view showing a dresser of a polishing apparatus in accordance with a further embodiment of the present invention.

DETAILED DESCRIPTION OF THE INVENTION

Hereinbelow, description is made with regard to embodiments of the present invention, with reference to Figs. 3 to 5. In Figs. 3 through 5, the same portions as those in Fig. 1 or the portions corresponding to those in Fig. 1 are designated by the same reference numerals as used in Fig. 1.

Fig. 3 is a view showing an example of a general arrangement of a polishing apparatus of the present invention.

The polishing apparatus includes a turntable 1 with a polishing pad 2 provided on the upper side of the turntable 1, a substrate holder or wafer carrier 3, a dresser 4 and an air cylinder 9 for urging the dresser 4 against the polishing pad 2.

The air cylinder 9 is a low-friction type and the kinetic frictional resistance generated when a piston in the air cylinder 7 is moved is about 0.44 kg or less. Air is supplied through the controller 8 to the air cylinder 9 in a direction for moving the dresser 4 in a downward direction (a direction for pressing the polishing pad 2) and is supplied through a regulator 10 to the air cylinder 9 in a direction for moving the dresser 4 in an upward direction (a

direction for canceling the weight of the dresser out).

In this polishing apparatus, the weight of the dresser tool 5 and the weight of the dresser shaft 6 are set in the regulator 10 and air is preliminary supplied through the regulator 10 to the air cylinder 9 in an amount sufficient for canceling the weight of the dresser 4 out. Therefore, when no air is supplied through the controller 8 to the air cylinder 9, the pressure applied to the polishing pad 2 is zero. Consequently, by adjusting the amount of air supplied through the controller 8 to the air cylinder 9, the pressure applied to the polishing pad 2 can be adjusted to an arbitrary value between zero and a value larger than zero. That is, the pressure of the dresser tool 5 applied to the polishing surface of the polishing pad 2 can be minimized to a level less than the weight of the dresser tool 5 and can be adjusted to an arbitrary value exceeding that level.

As is described above, by supplying air through the regulator 10 to the air cylinder 9 in a direction opposite to the direction of air supplied through the controller 8, the weight of the dresser 4 is canceled out. In this case, however, the air cylinder 7 of a conventional type shown in Fig. 1 has a problem such that when the pressure applied to the polishing pad 2 is set to be low by the controller 8, it is difficult for an actual pressure applied to the polishing pad 2 to be precisely controlled due to a frictional resistance (slide resistance) of the air cylinder. This problem can be avoided by using the air cylinder 9 of a low-friction type having a frictional resistance of about 0.44

kg or less. By this arrangement, the minimum pressure applied to the polishing pad 2 can be set to a level as low as, for example, 10 N (Newton).

In Fig. 3, reference numeral 11 denotes a torque transmitting pin for transmitting a torque of the dresser shaft 6 to the dresser tool 5. Reference numeral 12 denotes a ball bearing for supporting the dresser tool 5 relative to the dresser shaft 6 in a manner enabling the dresser tool 5 to be inclined relative to the dresser shaft 6.

Fig. 4 shows a polishing apparatus in accordance with another embodiment of the present invention.

In this embodiment, a dresser tool 5 is connected to a dresser shaft 6 by torque transmission pins 11 in such a manner that the dresser tool 5 is movable relative to the dresser shaft 6 in a vertical direction, while the dresser tool 5 is rotated together with the dresser shaft 6. As shown, each torque transmission pin 11 extends through a vertical through hole formed in a flange 6a fixedly connected to the lower end of the dresser shaft 6 with a clearance being provided between the outer surface of the pin 11 and the inner surface of the vertical through hole of the flange 6a. The torque transmission pin 11 is provided at its upper end with a large diameter head 11a.

When the dresser shaft 6 is located at an elevated position, a lower surface of the pin head 11a is engaged with an upper surface of the flange 6a of the dresser shaft 6, whereby the dresser tool 5 is supported by the dresser shaft 6 in a suspended fashion.

To effect dressing, the dresser 4 is moved to a dressing position above the polishing surface of the polishing pad 2. When the dresser shaft 6 is lowered at this position, a lower surface of the dresser tool 5 is brought into contact with the polishing surface of the polishing pad 2. Then, the dresser shaft 6 is further lowered (in a range such that there is no contact between a lower surface of the flange 6a and an upper surface of the dresser tool 5), to thereby enable the dresser tool 5 to rest under its own weight on the polishing surface.

As mentioned above, during dressing, the dresser tool 5 is disconnected from the dresser shaft 6 in a vertical direction and rests on the polishing surface of the polishing pad 2 under its own weight. Consequently, the dresser tool 5 is pressed against the polishing pad 2 under a low pressure equal to its own weight, whereby rapid wear of the polishing pad during dressing can be avoided.

Fig. 5 shows a dresser 4 of a polishing apparatus in accordance with a third embodiment of the present invention. In this dresser 4, the dresser tool 5 is supported relative to a bearing support member 15 through an automatic aligning roller bearing 13, in a manner enabling the dresser tool 5 to be inclined relative to the bearing support member 15. The bearing support member 15 is provided with a slide member 14 which enables the support member 14 to vertically move along a guide pin 6b, which extends downwards from a flange 6a formed integrally with a lower end of a dresser shaft 6. When the dresser shaft 6 is located at an elevated

position, the lower surface of the head 11a of the torque transmission pin 11 is engaged with the upper surface of the flange 6a of the dresser shaft 6 so that the dresser tool 5 is suspended from the dresser shaft 6. This is the same as in the case of the dresser 4 in Fig. 4.

Even when the polishing surface of the polishing pad 2 is inclined, the automatic aligning roller bearing 13 enables the dresser tool 5 to follow the inclined polishing surface and dressing is conducted under a pressure equal to the weight of the dresser tool 5. Therefore, a rapid wear of the polishing during dressing can be avoided.

In the above-mentioned embodiments, a polishing apparatus in which a polishing pad is provided on a turntable is taken as an example. However, this does not limit the present invention. A polishing apparatus in which a polishing plate comprising abrasive particles (an abrasive plate) is provided on the turntable may be used.